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RESEARCH ARTICLE

Analytical and Simulation Study of Energy Consumption Saving Principles

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ABSTRACT: Energy-saving is a very important issue that affects the end-users, power system quality and the global environment. Through the periodic energy bills of various energy agencies in Oman, it is possible to search for the causes of excessive consumption to reduce it with the search for the optimal solution with alternative energy sources. The main task of this research work is to help to reduce the electricity and energy costs by using Demand Side Management (DSM) approaches represented by the application of certain rationalization principles of energy usage and by using a model predictive control (MCP). As a result of that, an optimization algorithm for large-scale dynamic systems that take account of electricity costs, the work cycle, user requirements, system constraints and other input information is developed. The work used qualitative data from the perspective of the consumer, which was collected directly by the researcher or obtained from various sources related to the problem. An energy side management or simply energy demand response is proposed which ensures the optimum use of the equipments in the frame of a smart house.

KEYWORDS: Energy Consumption, Energy Saving, Rationalization principles, Demand-Side Management, Smart Homes.

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1. INTRODUCTION

Today, the world is in a state of panic and fear due to the emergence of some things on the surface, the most important is the energy consumption and depletion of energy resources available in nature. Developing countries, such as Oman, face a major problem in terms of access to electricity and rapid access to their energy reserves, which cause a depletion of their energy reserves[1].

It is clear that the building sector is among the most energy consuming sectors in the Sultanate of Oman and therefore needs to be improved through energy efficiency measures and rationalization principles of consumption in this sector and other sectors, until finding suitable alternative energy [2-3]. Intelligent home technology is a good choice for people who care not only about safety and comfort but also about energy saving [4-5].

Therefore, it is necessary to take advantage of modern equipment such as smart meters, smart devices and phase measurement units in homes, buildings, electricity and transport networks to gain the opportunity to assume more responsibilities by moving from passive to active customers [6-7].Conservation programs and reduced peak demand are aimed at reducing energy demand or changing demand at peak hours to fewer hours of activity without significantly affecting the consumer.

An energy side management or simply energy demand response is proposed which ensures the optimum use of the equipments in the frame of a smart house. The proposed system for the method is the formulation and subsequent optimization of the energy side management using a model predictive control (MCP). As a result of that, an optimization algorithm for large-scale dynamic systems that take account of electricity costs, the work cycle, user requirements, system constraints and other input information is developed.

Qualitative data from the perspective of the consumer are used directly by the researcher, or obtained, from various sources related to the problem. These data were used to study the benefits of using demand side management. This work will be the basis for future research in this area with the aim of broad-based development towards the goal of peak demand reduction and energy saving.

The practical significance of this research is that it examines a project of peak demand reduction that has been successful in reducing the peak demand for longer periods within a single community. The contributions of the research work can be summarized as follows:

1) This work presents an idea of decreasing the power consumption and energy saving by controlling over all the loads individually inside the house. It depends on detecting the peak time demand and reduces the load usage by switching off unwanted loads with a priority that is being set by the consumer [11].

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2). The result of research workreveals that the efficient and effective way for managing the appliances and loads in smart homes and buildings through the DSMis to investigate the optimization and control approaches of DSM from controlling the specific loads in homes and among multiple users of a community or area [12].

2. ANALYSIS OF HOUSEHOLD ELECTRICAL APPLIANCES

2.1 Electricity Consumption at Homes

The growth of domestic energy consumption can be explained by the widespread use of old inefficient devices as well as the increase in the number of electrical appliances. Today many families have two or three televisions and a refrigerator, and increasingly we have washing machines and air conditioners. Also, worth noting is the increasing number of digital electronic devices, without which today one cannot imagine daily life. Besides, the number of family homes, large apartments and the growing residential area is increasing [1-3].Figure 1 and Tables 1 and 2 show an interesting difference between energy consumption in heating and power consumption in household appliances. According to these tables, electricity consumption in homes is divided as follows [15].

Every household is of course different. They differ not only in the size and type of living space, the number of people, the equipment of the electrical appliance, but also in their lifestyle. This also corresponds to the range of values in the table above.

The prediction of electricity consumption is generated separately for the two main areas of consumption: the manufacturing sphere and the sphere of households. The former is reflected from economic forecasting at a macroeconomic level, while the second uses demographic projections, particularly projections of households [13-15].

The current assumptions relevant directly for the prediction of electricity consumption of small households - households can be summarized in the following points:

- Predictions assume significant energy savings for heating associated with the lower energy performance of buildings.
- The forecasts also include the assumption of savings associated with the continuous renewal of electrical appliances, respectively.
- The amount and use of household electrical appliances tend to grow, resulting in increased consumption not only in the other consumption sub-sector but also overall.

Table 1: Distribution of electricity consumption in households - total

Heating	Water heating	Other electrical appliances
60%	20%	20%

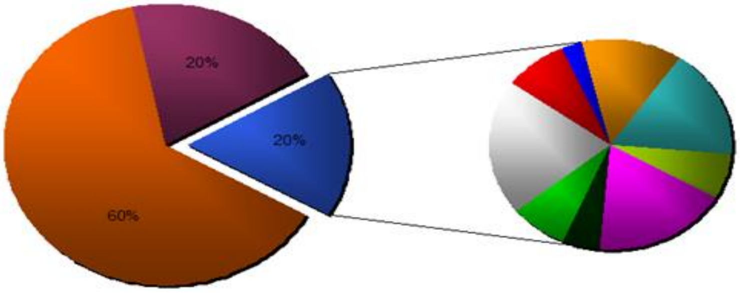

Figure 1Breakdown of electricity consumption in households

Table 2: Breakdown of electricity consumption in households - other electrical appliances

Cooling technology	🟪	18 %
Washing technology	🟥	13 %
Food and beverage preparation	⬜	20,7 %
Video technology	🟩	8,3 %
Audio technique	🟦	2,8 %
Office equipment	🟧	13,7 %
Lighting	🟦	16,6 %
Other	🟩 ⬛	10,9 %

3. SMART HOME CONTROL PRINCIPLES

To save energy, the rule says that devices must be turned off rather than left in standby mode. Most people do not realize any electronic or electrical devices that consume the most energy. Anyone who wants to obtain details of the energy consumption needs to obtain smart meters or adapters. By using the adapters, users turn on or off all electrical devices or measure consumption to reduce the unknown amounts of energy. In smart home applications, electrical appliances can be turned off remotely if necessary. Or residents deactivate all unnecessary electrical appliances by pressing a button when leaving home [17-18].

Oman should begin to study the applicability and adoption of smart domestic rules and regulations that provide 70% electricity through buildings that integrate energy systems, temperature control, lighting, sound, workplace, communications and LAN systems to provide management information and connectivity to the central computer system, where smart home systems are a way to significantly reduce energy bills [1, 18].

Smart technology has penetrated our lives and has become an integral part of them due to their comfort and well-being. "Electronics markets now boast many smart home appliances ranging from home-based smoke detectors to power-controlled heating thermostats to smart lighting," said Falco Hansen of the German Technology Portal [19].

The smart home must be able to act automatically and automatically, anticipating and responding to the needs of consumers based on the patterns of lifestyles acquired and the interaction in real-time to increase comfort, awareness, comfort, cost, and energy savings.

Smart homes for the future are expected to be dynamic assets that balance home production and consumption with distributed energy resources, reduce demand for loads by improving more energy-efficient products, responding to signals that change demand at times when Network is less stressful and Supports a more reliable network infrastructure [13-15].

3.1 How does a Smart Home Save Energy?

The smart grid consists of a power grid with communications, controllers, computers, SCADA and other new technologies working together to respond to the integration of energy sources into the network, demand side management, and overall response to the expected continuous changes in power networks.

Smart systems and devices help save energy by helping users control energy efficient appliances in modern ways. For example, according to the Fraunhofer Institute, intelligent home control can save up to 40% of heating costs. This is definitely the ideal scenario we look for. Of course, heating costs depend on many factors; so many manufacturers report savings of up to 30 percent or more annually, which seems realistic and achievable. Therefore, the first step toward more efficiency from the point of view of energy saving is that the smart home is still the best choice.

A big trend in the smart home sector is becoming visible today: owners are producing their own electricity through a rooftop system projector. In the future, intelligent control of construction services will ensure that unused electricity is stored or used for devices where the power source can be changed in a timely manner [8, 16].For example, an intelligent heat regulator (thermostat) is an essential part of an energy management system because the home heating and cooling system is one of the largest energy consumers in the home. Smart home systems make many heaters programmable. Using the programmable heat regulator, you can adjust the temperature at different levels during the specified times throughout the week. If they are not at certain times during the day, the heaters will be turned off automatically. If they arrive home ahead of time, they can access their smart home through the mobile application. For example, it is not necessary to heat up when there is no one at home during the day. When the window is open, the heating is automatically generated in the smart house. Of course, heating can be controlled manually if necessary.

While 34% of the typical energy bill is spent on lamps, 25% of utility bills are spent on single lamps. Reduce your energy consumption by simply turning off lights when you do not need them with automatic timers and motion detectors. You can also use dimmer devices to reduce electricity cost and save energy.

Smart homes allow users to track the use of energy over time. They can also get information of how much they pay for what they have spent. This will gradually affect end user behavior and help him to be more responsible with energy savings [16-20].

4. ANALYSIS OF ENERGY CONSUMPTION IN ELECTRICAL INSTALLATION SYSTEM

The methods, procedures and the capabilities that can be used in reducing the electricity power consumption, and how to blend some techniques to attain the best results. The common areas of the house (especially corridors, cellars, staircases, shared rooms - laundries, prams, drying rooms, etc.) are used, illuminated, heated and ventilated (air conditioning is not yet in a residential building). These common rooms or spaces were illuminated during one month with different types of bulbs, with classic bulbs for some spaces and with energy saving bulbs for other spaces. Not only from an economic but also from an energy point of view, it is worthwhile to pay attention to the issue of the verification of consumption values in case of interventions in the electrical distribution system[19].

4.1 Energy Saving using Electrical Installation System Rationalization Principles

The current global trend is characterized by the promotion of energy-saving technologies. For this purpose, four groups were presented in energy efficiency (A to D). As soon as the building is equipped with smart control systems, it is allocated to one of these categories. The potential savings in heat and electricity for each category can be calculated according to the type and purpose of the building. Then, the C class values are used as criteria to compare the performance [20].

Classification of energy performance classes of buildings:

A. High Energy Efficiency Building Automation and Control System (BACS) and High Performance Building Management System (TBM)
B. Advanced BACS and TBM
C. Standard BACS
D. BACS without energy efficiency function

Therefore, to decide whether the electrical installation system is being used in a commercially designed building or not, it can be decided simply depending to which of the energy performance classes the building is included.

In residential buildings, it is necessary first to describe as much as possible the activities of all functions used in the building and it is then possible to decide whether to use any of the control systems. It is not just about the usual functions, including switching and dimming of lighting, including scenes, heating, ventilation and air conditioning control, including time and other programs, control of shading technology, windows and doors, switching of socket and other power circuits, but also cooperation with many other areas of functions [18-20].

4.2 Rationalization of Electricity Consumption in Lighting

In the past years, the electrical energy sector encouraged local industrialization of energy-saving fluorescent lamps as an alternative to incandescent bulbs. This helped supporting the presence of such kind of lamps in the local market to sell it at an acceptable price.The consumption of electricity due to lighting process is about 7% of the total energy consumed at the level of the Sultanate.

4.3 General lighting of homes

Energy consumption due to lighting at homes can be reduced by 15% by the following procedures [17-20]:1) Using more efficiently the day light2) Turn off the light in non-occupied places.3) Having clean lighting equipment.4) Replacing conventional bulbs with energy-saving lamps.5) Replace the magnetic transformer of the fluorescent lamps with an electronic transformer because it generates 20 to 30% of the electricity consumption as compared to the magnetic one [7].

Here are some important instructions and guidelines to follow:

A- Do not catch the bulb from its outsider tube.
B- Hold the bulb of the douse and the plastic when installing or removing it.

In the conventional bulb, the light stems from heating the internal suppository wick and therefore 90% of the energy consumed in the bulb is missed in the form of heat generating a high temperature in the place.

Figure 2 Conventional ordinary bulb. Source:www.sangyug.com

Wrong: in the normal bulb, the light stems from heating the internal suppository wick and therefore 90% of the energy consumed in the bulb is missed in the form of heat.

Figure 3 Illustration of fluorescent bulb. Source: www.fovitec.com.

Right: There is no wick in such bulb and therefore no heatgenerated in the place.

4.4 General lighting of roads and streets

The Energy or electricity Sector set the standards that should be followed in road renovation and lighting design so that it can be used when preparing lighting in new ways.

The Ministry of Electricity and Energy coordinates with the municipalities and the Ministry of Finance for ensuring the quality and efficiency of road lighting for the public interest by providing projects that improve the efficiency of street lighting. This is characterized by implementing many lamps of different types and capabilities including low-efficiency or high-capacity bulbs, as well as extreme glow on many streets.

4.5 Government buildings

Government buildings are described by a display and manifestation of excessive energy use, whether for lighting or for operating appliances and equipments.

Therefore, the main duty of the electricity and energy sector is to warn the Ministry of Electricity and Energy to take step actions to save energy in most of its buildings [14].

4.6 Rationalization of Electricity Consumption in Air-conditioning System

Air-conditioning system is one of the forms of heating and cooling systems, whether indoors or outdoors, besides heaters operating on fuels, natural gas and solar energy or electricity.Using air conditioning system is therefore one of the main sources for the rise in the electricity bill [20]. There are different types and capabilities for the air conditioning systems, so it is necessary to know how to deal with them to achieve the required savings in the electricity bill.

The principle of operation of air conditioner system: It depends on the evaporative cooling fluid (Freon) to generate the required cool. Freon gas is a non-flammable gas that is converted into a gas by absorbing heat from the surrounding area. Freon is then compressed by a piston into the condenser which operates on cooling Freon to a liquid through a capillary tube. Thus, this process of conversion from gas to liquid and vice versa is constantly repeated.The capacity of some air conditioners available on the market is as shown in Table 3:

Table 3: Some cooling capacities available on the market

Cooling		Capacity (kwatt)	
Tons	BTU	Coefficient = 8.5	Coefficient = 10
1	12000	1.4	1.2
1.5	18000	2.1	1.8
2	24000	2.8	2.4
2.5	30000	3.5	3

Source: energyguide.nrcan.gc.ca. (Note: BTU – British thermal unit of heat)

Table 4:The limitation of the cooling capacity in BTU based on the surface of the area in square meter

Note: 1 kWh = 3415 BTU.

Area (m^2)	Cooling
9-23	5000-6000
23-37	6000-8500
37-51	8500-11000
51-81	11000-15000
81-111	15000-19000
111-148	19000-24000
148-167	24000-27000
167-260	27000-33000

Source: energyguide.nrcan.gc.ca.

Cooling capacity is set according to the area to be cooled. Table 4 illustrates the limits of the cooling capacity in British units of heat (BTU) depending on the area of the space in square meter [19-20].Experts evaluates that each square meter requires around 333 BTU. This is non-estimation because dimensions of the space and the size of furniture affect the capacity required to cool such space.

4.7 General guidelines for air conditioning users [20]

1. Close the doors and windows to prevent the leakage of air and shading the room by closing the curtains before operating the air conditioner, which reduces the use of air conditioning by 10% -20% and consider the installation of air conditioning in the shade to reduce consumption by about 10% [15].
2. In some summer days the fan is sufficient to cool the temperature of the place.
3. Read the method of use well in order to follow.
4. Set the temperature to not less than 25 Celsius because it saves consumption by 6-8% and does not use air conditioning when the temperature is appropriate within 25C.
5. Switch off the air conditioner before leaving the room.
6. Sponsor the use of the appropriate air conditioning capacity of the place to be cooled because the use of a device less than the required amount causes excessive operation and poor performance of the device while choosing a larger volume leads to high humidity levels and low performance efficiency.
7. Regular maintenance of the air conditioning system by cleaning the air filter as well as ensuring that all the moving parts in the air conditioner operate easily and that the movement of the air conditioner is easy and working efficiently.
8. Check the air conditioning system immediately by specialists in the case of a sense of non-cooling as appropriate.
9. Avoid being thermostat air conditioner near the lamps or source of heat as well as avoid the use of dehumidifier while operating the air conditioner.
10. When buying an air conditioner, choose the most efficient device, ie the least electricity consumption, and this is identified by the energy efficiency card affixed to the device
11. Also when buying, choose a device that has a temperature control device within the programmable thermostat, which is a power saving button.
12. When operating the air conditioner in summer, the device after reaching the appropriate cooling degree (according to the temperature controlled) to raise the temperature (ie lowering the degree of cooling) gradually and then stabilize at an appropriate temperature until the device is separated, To the appropriate

temperature (according to the temperature controlled) to reduce the temperature (ie reduce the temperature) gradually and then stabilize at an appropriate temperature until the separation of the device, which performs well and save energy by 1-3% [15].

4.8 Rationalization of Electricity Consumption in Hot Water Heaters

This research work is also concerned merely with electric heating, since the greatest amount of energy can be saved by automating heating and ventilation process.

1. Water heating is a process of heat transfer using an electrical source to heat the water above the initial temperature. For cooking, cleaning, bathing and heating. The industry also uses hot water for many purposes [19-20].
2. In homes, water is usually heated by water heaters, boilers or basins. These mineral reservoirs that heat the water continuously do not produce hot water at a predetermined temperature. Hot water is rarely obtained naturally, possible from natural hot springs. The temperature varies according to the consumption rate and becomes cooler with increased consumption and flow [16-18].
3. If there is a good location for heating, installation and maintenance, the use of storage heaters is an economical option. Energy is consumed only when water is heated and subsequently consumed in the event of a drop-in water temperature due to heat loss caused by insulation. Thus, the value of the heat loss coefficient is an important factor in the selection of the heater. This parameter refers to the amount of heat consumed per liter of water when boilers are kept in hot water for 24 hours at a specified temperature. The parameter is often listed on the manufacturer's label. Another indicator of heating efficiency is the energy consumption category (A ++, A +, A, B, C ..) [20].
4. General guidelines, for example, for automatic washing machine users:
5. Do not operate it unless the washing machine is full. It consumes the same amounts of electricity, hot water and soap when using a full or half-full washer.
6. Use hot water for clothes is very dirty only.
7. Use cold water in the rinsing process.
8. Disconnect the power from the washing machine if not in use.
9. When buying a washing machine, choose the most efficient, for example, the lower consumption of electricity and this is determined by the energy efficiency card affixed to the washing machine.

5.Model Predictive Control (MPC) Implementation

Currently, there are many mathematical tools that can be used to formulate an approach demand response. The most common is its formulation as an optimization task, which can be solved by various methods. Apart from the means of the optimization method described and used in this work, i.ethe predictive control model and methods for solving them, other possibilities are used. These are mainly game theory, dynamic programming, stochastic programming, and others.

5.1 Mathematical Model and Data Analysis of DSM

The predictive control model is a modern method of control in which action on the system is determined by the optimization method. Such can be, for example, a linear or quadratic problem. The basic requirement for MPC management is the ability to create a sufficiently accurate system model. For example, it can be identified from the measured data during the experiment. Without a model, MPC control cannot be applied. Based on the characteristics of your system, you choose the correct trajectory for your system depending on the control action you choose. Hence, MPC helps you to choose the optimal control action that leads your system exactly through an optimal trajectory that is very near to the desired trajectory. MPC has certain advantages such as it handles multi input multi output systems that might have interaction between their different inputs and outputs as shown in Fig. 4.

If there are any constraints or limitations, MPC controllers solve all these limitations while it satisfies the desired trajectory of the system. This means that it can handles all constraints and limitations and it has a preview capability which helps determining and predicting the future behavior of the system trajectory.

MPC is defined almost always for systems described by state space representation. Let's have a discrete system described by the state equations as follows [69-70]:

$$\mathbf{x_{k+1}} = \mathbf{Ax_k} + \mathbf{Bu_k} \qquad (2)$$

$$\mathbf{y_k} = \mathbf{Cx_k} \qquad (3)$$

where x, u, y represent required quantity, control manipulated signal and output measured quantity of the system. MPC is then described as:

$$\mathbf{J} = \sum_{\mathbf{k=1}}^{\mathbf{N}} \mathbf{A_{ek}}(\mathbf{e_k})^2 + \sum_{\mathbf{k=1}}^{\mathbf{N}} \mathbf{A_{uk}}(\mathbf{u_k})^2 \qquad (4)$$

Where J is the cost function, let's say of consumption, e_k is the difference between the desired input value $x_k$and the actual output y_k, but u_k is the difference between x_k and the predicted value of the output generated by the optimizer.

5.1 Data Collection

The systematic data collection for energy demand and consumption was conducted for Sohar and Wadi Aljizzias over one year and also for one day for the whole District of Dhofar and the databases in Tables 5 and 6 were selected based on the systematic record of main interconnected network of Oman.

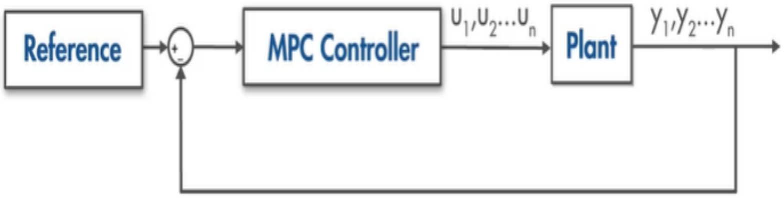

Figure 4 Block diagram of a MPC model

Table 5: Power consumption rates over almost one year in Sohar

No.	Month	Reading (kWh)	Consumption per month (kWh)
1.	August/2017	16257	433
2.	September/2017	17377	1120
3.	October/2017	18569	1192
4.	November/2017	19933	1364
5.	December/2017	11363	-8570
6.	January/2018	12880	1517
7.	February/2018	14388	1508
8.	March/2018	15824	1436

Table 6: Power consumption rates between 07/2017and 06/2018 in Wadi Aljjizi

No.	Month	Reading (kWh)	Consumption per month
1.	25-Jul-17	308512	1537
2.	27-Aug-17	310829	2317
3.	24-Sep-17	313405	2576
4.	24-Oct-17	315664	2259
5.	21-Nov-17	317957	2293
6.	20-Dec-17	320041	2084
7.	22-Jan-18	321999	1958
8.	21-Feb-18	323483	1484
9.	23-Mar-18	326380	2897
10.	19-Apr-18	327996	1616
11.	18-May-18	332299	4303
12.	24-Jun-18	333292	993

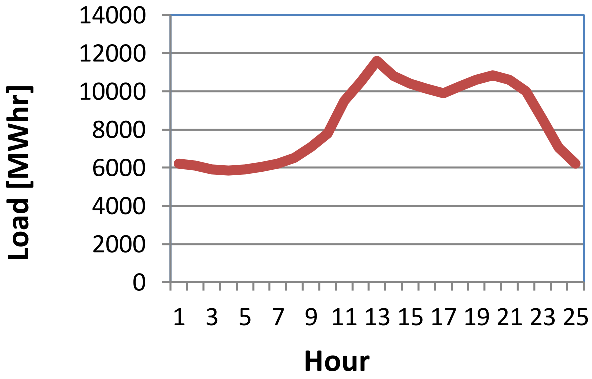

Figure 5 Example of Power system Load in one day in Oman

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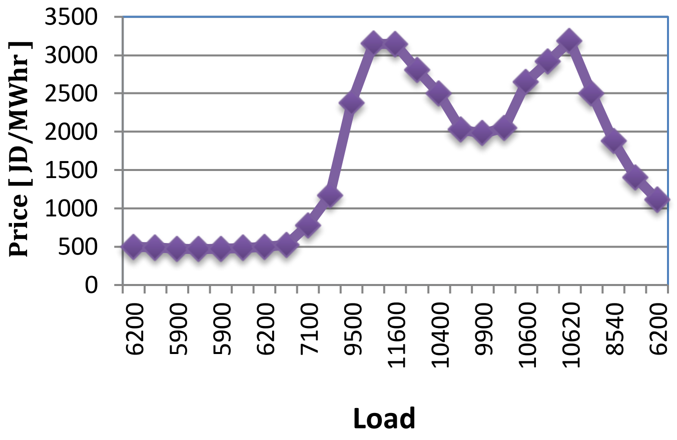

Figure 6 Example of Electrical energy price in the Market in Oman.

Figures 5 and 6 show the fluctuation in the loading capacity and electricity price recorded for one whole day and therefore the electricity price on the daily market occurs in the morning hours before noon and in the evening peak. By managing consumption using MPC, we try to limit these peaks by reducing demand and, ultimately, to save production costs.

5.2 Implementation of MPC using MATLAB

Given that certain individual calculations of the optimization task were performed in the individual studies, it was necessary to generate the input data automatically based on MPC model. The Matlab program was selected for this action, in which scripts were created to fill the input file group. In the same program, a MPC system model was also mathematically created, and its state description is also part of the input data set.

5.3 Algorithm and Working Principle of MPC

The strategy of MPC controller is to predict the future behavior of the output of the plant. Therefore, it uses an optimizer to ensure that the output tracks the desired reference.

The following example works through steps. Let's say that the energy consumption per year or per month of a building controlled by MPC to make it follow the red line shown in Figure 7. The red line represents the required consumption in one year. MPC controller works in such a way that it divides the whole year into prediction horizons representing the months of the year and time samples represented by small time intervals k where each sample k represents one whole day in a month.

The MPC needs to find the best trajectory path of consumption during the whole year that is the closest to the reference trajectory represented by the red line. So, it simulates multiple future scenarios of trajectories along which the consumption may move. It also tries to minimize the difference between the reference and the actual value of consumption represented by e.

While minimizing the cost function in Eq. 4, the MPC makes sure that the consumption moves directly along the prescribed trajectory. At each time sample or step, the MPC deals with and applies only the first optimal sequence to the plant, represented by e_1 and disregards the rest. Based on this, the plant travels to the next step of consumption at k+1 and the controller gets a new measure of the consumption. Now the prediction horizon moves forward by one-time step and the controller repeats the same cycle of calculation to compute the optimal consumption value for the next time step and horizon.

The main algorithm for MPC is then done as follows:

1. Calculate a new state x_k.
2. Solve it using the optimization method described by eq. 4 to find the cost function.
3. Determine the control manipulated signal for the system $u_{k+1}=u_k+u_0$, where u_o is the initial value of u.
4. k=k+1.
5. Go to step 1.

Figure 8 shows an example of energy management load in a working day during the autumn, where the positive values represent a delay in consumption (device shutdown) and negative value represents the operation of the devices. Shedding values are determined to reduce power consumption as much as possible and to balance the load scheme as much as possible. So, the main goal was to shift consumption from midday during the weekend and from the afternoon peak to the morning hours when the loading capacity was smaller. From calculating the maximum load shedding potential in the specified area, 84.6 kilowatts per hour can be shed during the working day and 170.7 kilowatts per hour over the weekend, representing between 3 to 10% of daily energy consumption (Table 7). When calculating the difference in the cost of purchasing electricity at average prices in the daily market, they saved $ 6,289 per year.

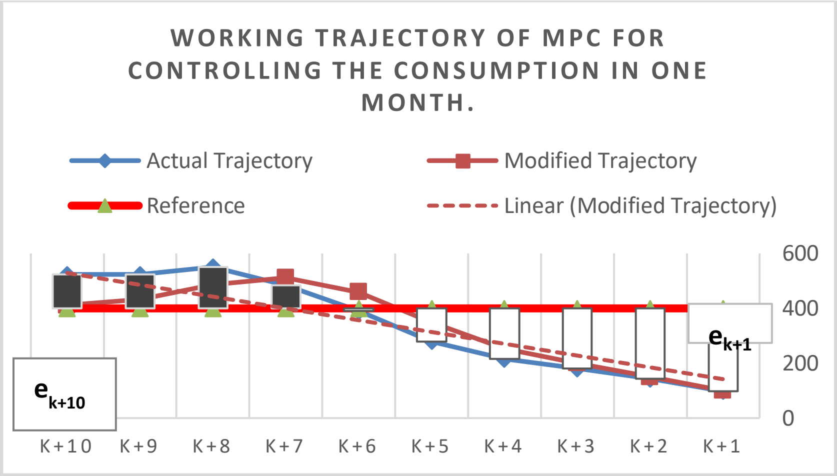

Figure 7 Working trajectory of MPC for controlling the consumption in one month.

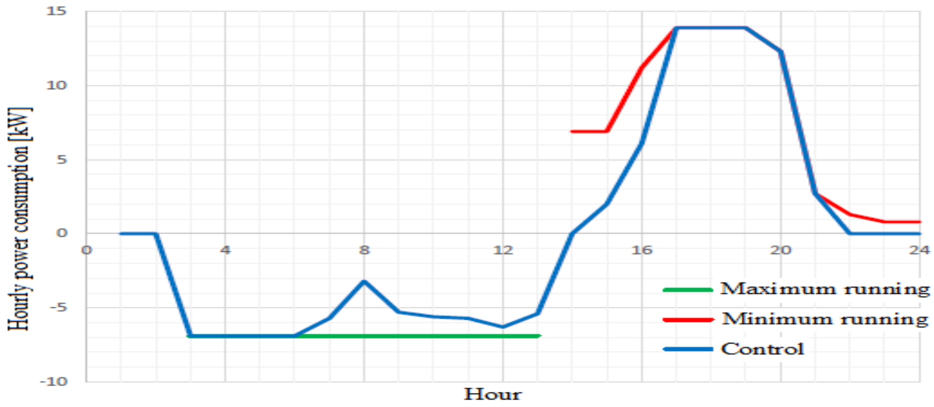

Figure 8 Load duration curve control in one day in autumn

Table 7: Estimation cost savings of energy purchase during control

		Spring		Summer		Autumn		Winter	
		Working day	Weekend	Working day	Weekend	Working day	Weekend	Working day	Weekend
average daily consumption of the area [kWh]		2166,3	2 270,5	1 6.906	1 6.947	2 1.227	2 2.020	2 6.449	2 7.615
maximum daily potential shedding	[kWh]	8.46	17.07	8.46	17.07	8.46	17.07	8.46	17.07
	%	3,91	7,52	5.00	10.07	3.99	7.75	3.20	6.18
used daily potential shedding	[kWh]	5.26	8.17	4.47	4.44	6.48	11.03	5.53	10.4
	%	2.43	3.60	2.64	2.62	3.05	5.01	2.09	3.77
Days no.		66	26	66	26	65	26	64	27
The difference in energy costs per day		7,26	7,54	8,03	9,02	22,06	33,15	22,06	42,29
The difference in energy costs for the whole period [USD]		479	196	530	235	1 434	862	1 412	1 142
Total difference per year [USD]		6289							

6.SIMULATION STUDY OF ENERGY CONSUMPTION IN ELECTRICAL INSTALLATION SYSTEM

6.1 Practical Example of Using Rationalization Principle

In the next example, for studying the difference in the energy consumption between conventional electric appliances and energy efficient appliances, conventional filament lamps were used in common areas in a large building in Dhofar District and due to the many disadvantages described previously for the following reasons:Low purchase price; Relatively long service life of several thousand hours of operation; Fast start-up of maximum light on; A large number of switching and switching cycles.

Fluorescent lamps are installed in common areas for the following reasons:Greater light intensity; Low number of switching cycles; diffused light suitable for the working environment - technical rooms. Energy saving bulbs is operated for the following reasons:Outdoor lighting; There is no demand for high light intensity; Low switching - the fluorescent lamp is lit continuously during the night.

Table 8 shows the data collected for one large building having 4 floors in addition to the cellar spaces and ground floor in Dhofar District which was taken as an example for the typical loads connected to the main grid of this District. The electrical Appliances were considered to work for 10 hours daily. Different floors with different distribution of electrical lighting systems result in different values of energy consumption for each floor. Using energy efficient light bulbs greatly can help the reduction of energy demand and consumption. The values and data of the electricity consumption were collected and recorded for common areas in a standard apartment building in Dhofar district in Oman for the period of 07/2017 to 06/2018. The power consumption values were recorded from the electricity bill for different months.

Furthermore, automatic washing machines of different types, conventional washing machine with energy efficient machine of A+ were explored and examined under different operating conditions to obtain a clear figure of energy consumption. The measured data are shown in Tables 9 and 10 with the simulation illustrated in Figures 9 and 10.

Table 8: List and number of elements connected to the power distribution of common areas of a large building

	List and number of installed devices						
	Bulb 40W	**Bulb 100W**	**Eco bulb 10W**	**LED (5W)**	**Emergency lighting 1W**	**Electric Door Lockssystem 10W**	**Power consumption rate**
Cellar spaces	6	6	0	0	0	0	8.4kWh
Ground floor	2	2	2	2	2	2	3.3kWh
1. floor	3	6	0	0	3	0	7.2kWh
2. floor	6	3	0	0	3	0	5.4kWh
3. floor	0	0	6	6	2	0	920Wh
4. floor	3	3	3	3	0	0	4.6kWh

Table 9: Estimated amount of hot water used

Description		Washer Type	
		Large Washer (gallons)	**Front Door Washer (gallons)**
1	Hot wash/warm rinse	40	20
2	Hot wash/cold rinse	30	10
3	Warm wash/warm rinse	30	15
4	Warm/cold rinse	15	5

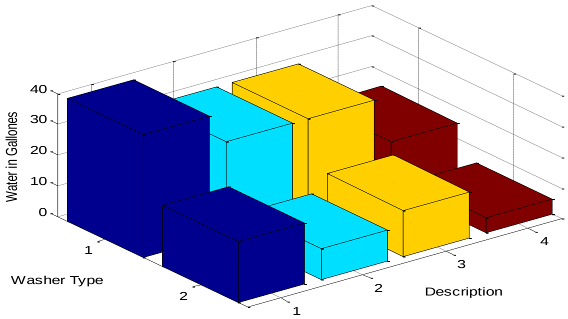

Figure 9 The amount of hot water used for the types of washing machines by size

Table 10: Estimated amount of water of washing machines with the upper door

Description		Water Usage in Gallones
1	Small size	20
2	Medium size	27
3	Large size	34
4	Extra large	40

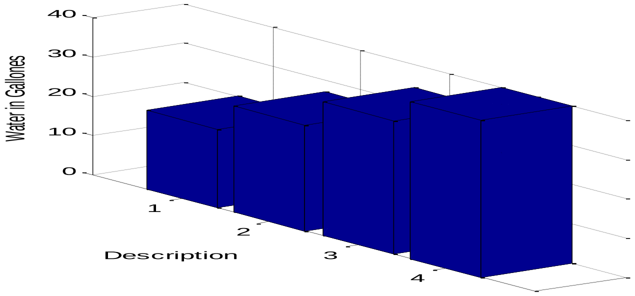

Figure 10 Quantity of water used (estimated) for washing machines with upper door.

Table 11: Comparison of electricity consumption with wash cycle when reducing the control temperature

Description		Water Temperature	
		Water temperature 50 c(Usage kWh**)**	**Water temperature 60 c(**Usage kWh**)**
1	Wash\rinse	6.5	8.3
2	Hot\hot	4.9	6.3
3	Hot\warm	3.4	4.3
4	Hot\cold	3.4	4.3
5	Warm\warm	1.9	2.4
6	Warm\cold	0.4	0.4
7	Cold\cold	6.5	8.3

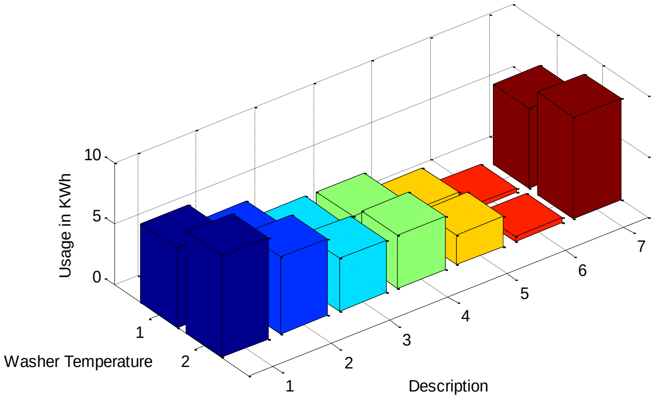

Figure 11 Electricity consumption values for washing machines when decrease temperature to 50 °C and 60 °C

When the temperature of the washing process is reduced from 60 ° C to 50 ° C, electricity consumption is reduced by about 20% - 50% as shown in Table 11 and Figure 11.

The previously illustrated data and reports from IRENA 2016 and some other studies identified which factors may affect the non-adoption of energy efficiency technologies in the household sector. These factors have been grouped with a clear distinction between what is induced by the energy product itself and what is derived from the context. The report also analyzes various domestic energy technologies. The main objective was to point out the quantification of determinants in order to understand what is behind the decision to invest in household energy. The number of factors influencing decisions on energy efficiency technologies in households is undoubtedly extensive. The following issues could be obtained for energy rationalizations:

- The second phase of program of energy efficiency standards and labeling for household appliances.
- Creating and activating a financing system in banks to facilitate having solar water heaters in the household sector.
- Energy saving in street lighting.
- Rationalization of energy use in public buildings.
- Energy conservation in drinking water plants and sewage plants.
- Energy conservation in hotels.

The savings expected to be achieved through implementing the mentioned procedures have been identified. These procedures include the participation of some ministries (industry and foreign trade, housing, local development, state for environmental affairs, and tourism).

7. CONCLUSION

In this research work, we addressed the analysis of electrical energy consumption values that bring to light and explain the general issue of the operation of electrical equipments and offer useful information about energy saving. Also, explained the usefulness of Model Predictive Control (MPC). One objective of MPC is to coordinate and control a large portfolio of power consumption and production. From the point of view of MPC, the larger the area considered in the control and the more devices involved in management, the average estimates will be closer to the actual values.

The results of the analysis have shown that the maximum daily consumption management potential. In conclusion, we would like to summarize that consumption management has very little potential, taking into account all the limitations on the part of customers and the costs of the current technology considerably outweigh the benefits of these systems.

In conclusion, the future of housing demand reduction will be socially and technically, making progress in the technical field, including the continuous improvement of the efficiency of electrical products, the use of off-peak tariff, management of smart devices and smart meters. Success in building relationships at the community level and individual family is to promote widespread expansion in the maximum demand reduction hypo research work.

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